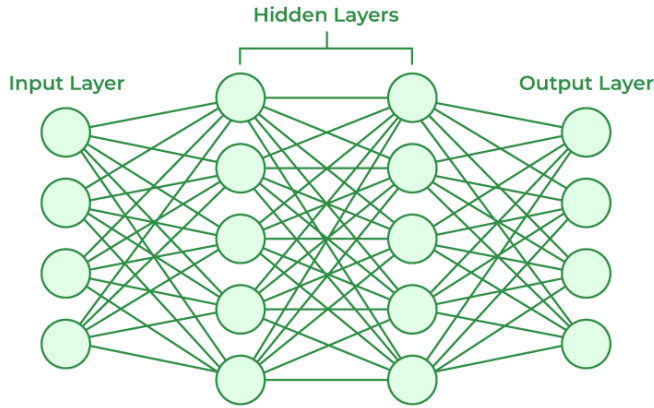
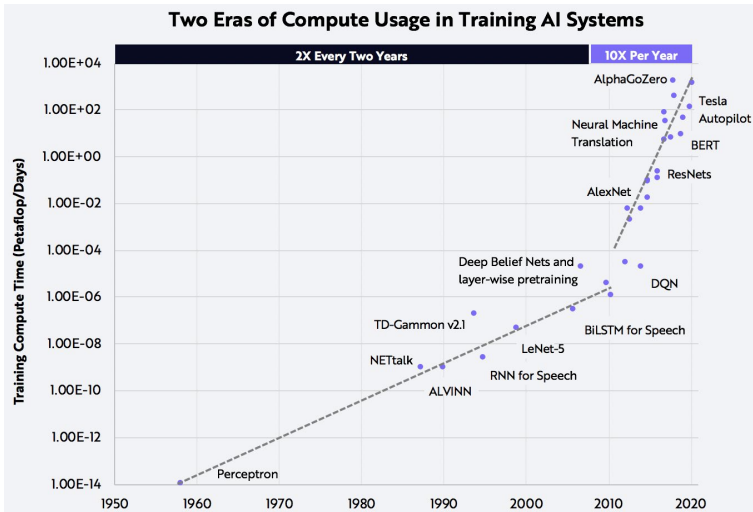


# The Amazing Success of ML / Neural Networks Today

## Artificial Neural Networks



300,000x more power in the last 6 years  
(vs. 8x predicted by Moore's Law)



Source: ARK, OpenAI, <https://arkinv.st/2ZOH2Rr>

... come with a price ...

e.g., training ChatGPT-4

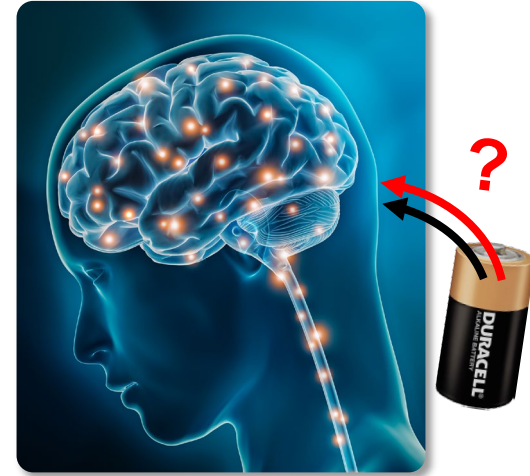
\$ 100 Million Dollar

🍃 1.287 Gigawatt hours EL

→ AI everywhere, sustainability?

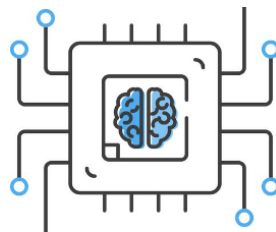
Source: <https://tinyurl.com/CGPTEnergy>

... vs. energy constrained neural computation



## Neuromorphic Computing

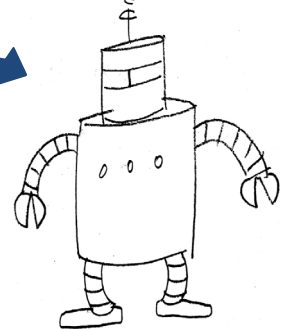
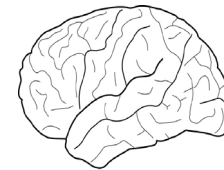
Computing elements  
(hardware and software)



developed by  
how the brain  
processes  
information

## What we do

'Neuromorphic Brains' for Robots

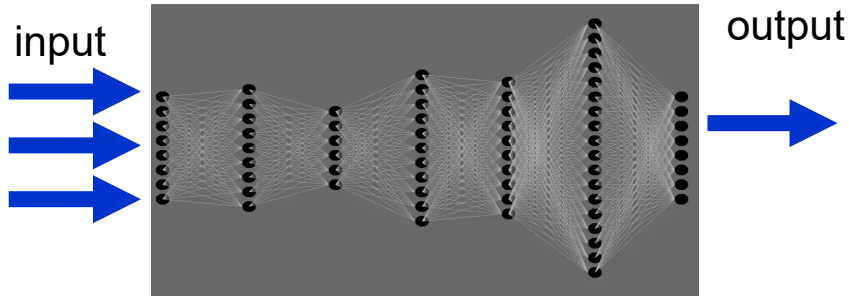


# What is Neuromorphic Computing?

## Neuromorphic Hardware

### Neuro-inspired Computing Concepts

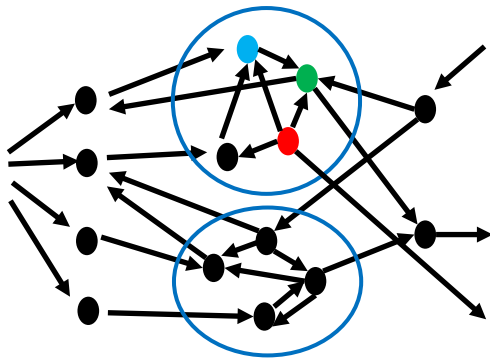
#### Spiking Neurons



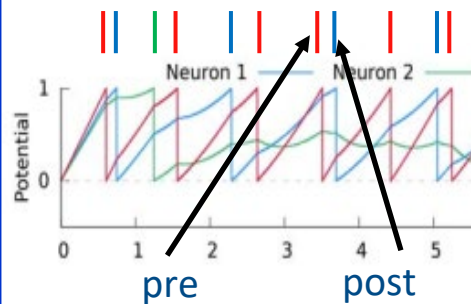
#### Advantages

- Sparse computation
- Low latency
- Reduced computing power consumption

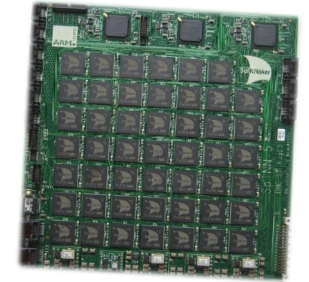
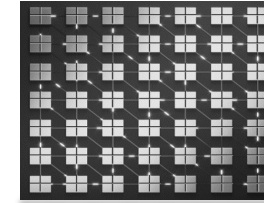
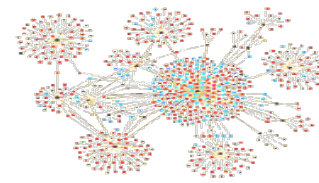
#### Small World Networks



#### Local Learning



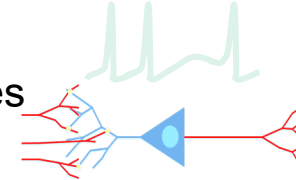
#### Computing Systems



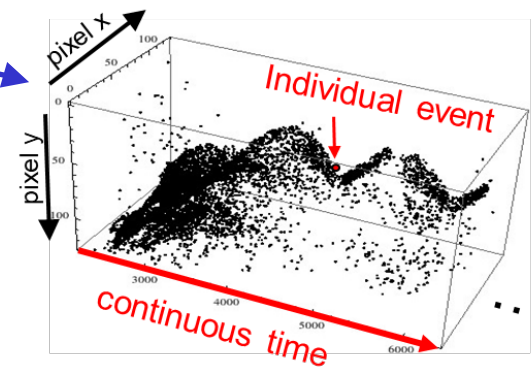
#### Characteristics

- Parallel (fine-grained)
- Event-based
- Memory integrated

Programmed with neural architectures or local learning



#### Sensors, eg. Event Cameras



#### Sensor Features

- Change of illumination produces event
- Asynchronous updates
- Microseconds latency, up to Mevents/sec

# Neuromorphic Computing Systems and Resources

## NCS Laboratory, 1536 Borggården



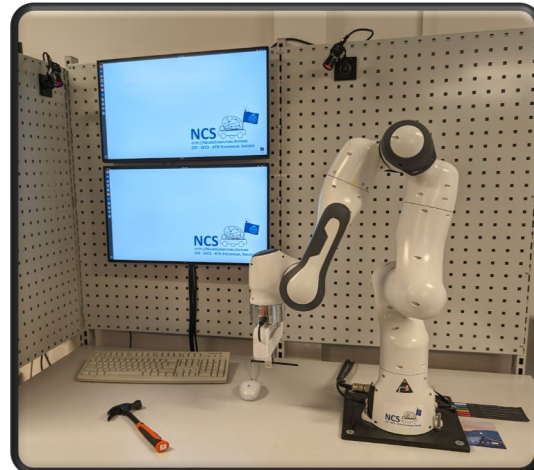
Electronic Development



Robot Exploration Arena

## Neuromorphic Projects

### Example Robots





# Neuromorphic Computing Systems and Resources

## NCS Laboratory, 1536 Borggården



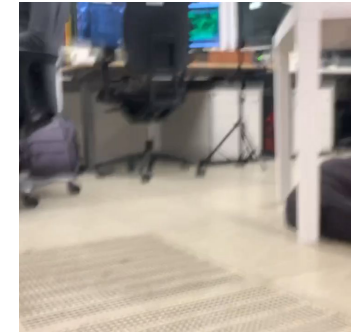
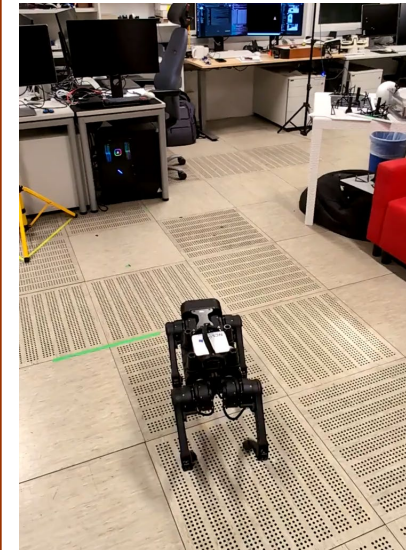
Electronic Development



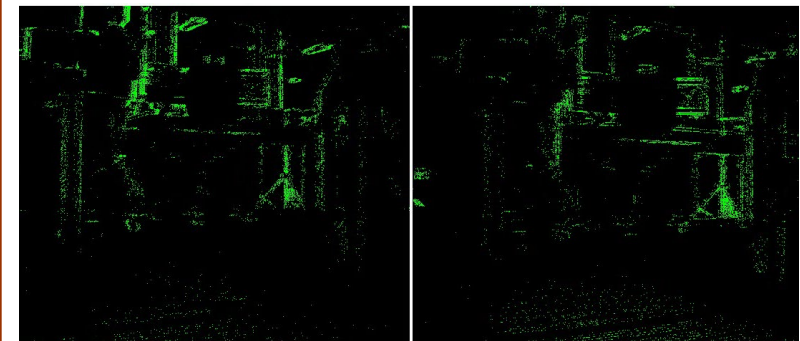
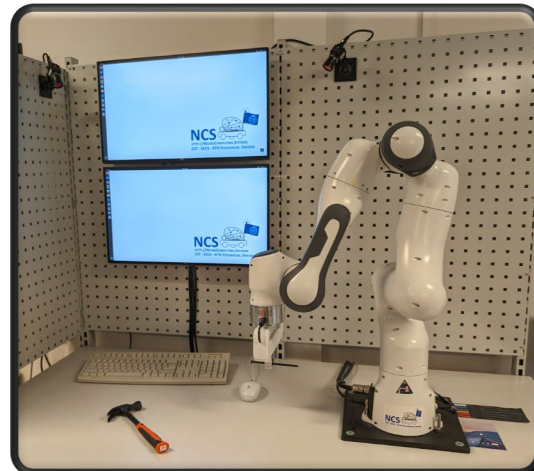
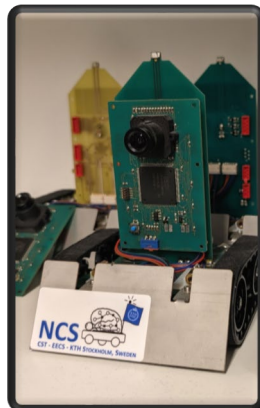
Robot Exploration Arena

## Neuromorphic Projects

### Real-Time Robot Vision



### Example Robots





# Neuromorphic Computing Systems and Resources

## NCS Laboratory, 1536 Borggården

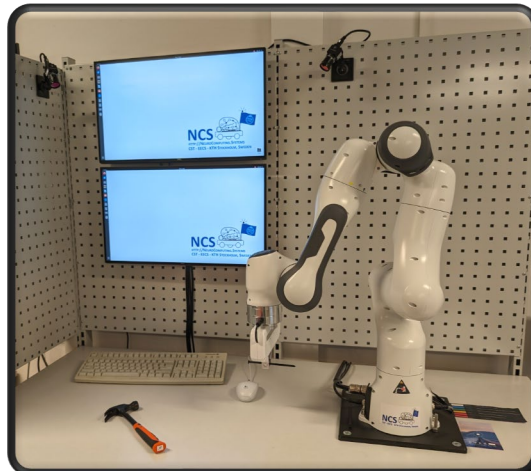
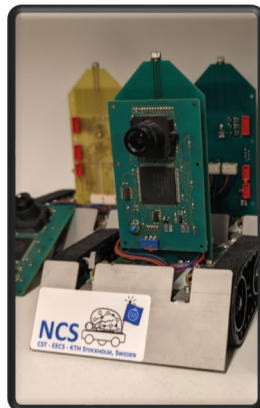


Electronic Development



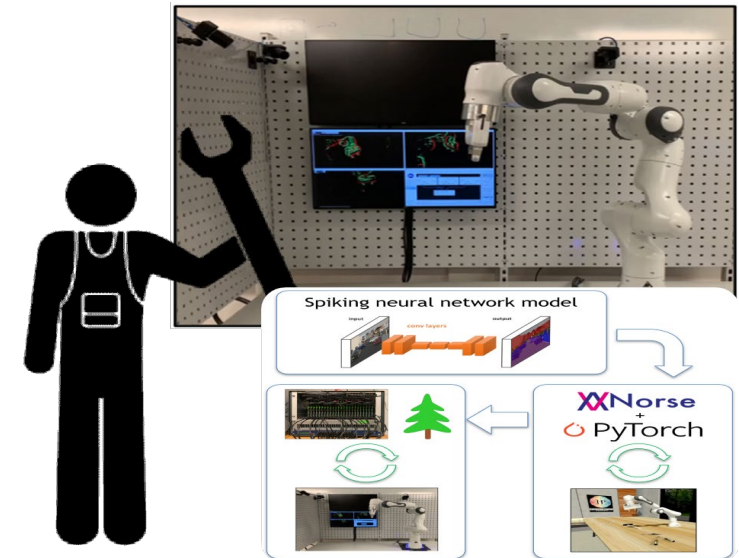
Robot Exploration Arena

## Example Robots



## Neuromorphic Projects

### Human-Robot Collaboration



Low latency tool tracking  
→ intuitive human-robot collaboration

More information?

**NCS**

[HTTP://NEUROCOMPUTING.SYSTEMS](http://neurocomputing.systems)  
CST - EECS - KTH STOCKHOLM, SWEDEN

